



# UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
United States Patent and Trademark Office  
Address: COMMISSIONER FOR PATENTS  
P.O. Box 1450  
Alexandria, Virginia 22313-1450  
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/943,222	08/31/2001	Hideki Hirayama	1794-0142P	8855
2292	7590	03/09/2004	EXAMINER	
BIRCH STEWART KOLASCH & BIRCH PO BOX 747 FALLS CHURCH, VA 22040-0747			SONG, MATTHEW J	
			ART UNIT	PAPER NUMBER
			1765	

DATE MAILED: 03/09/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

## Office Action Summary

Application No.

09/943,222

Applicant(s)

HIRAYAMA ET AL.

Examiner

Matthew J Song

Art Unit

1765

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --  
**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

### Status

- 1) ☒ Responsive to communication(s) filed on 18 December 2003.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

### Disposition of Claims

- 4) ☒ Claim(s) 1-27 is/are pending in the application.
- 4a) Of the above claim(s) 10-18 is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1-9 and 19-27 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

### Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

### Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some \* c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

### Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)  
Paper No(s)/Mail Date \_\_\_\_\_
- 4) ☐ Interview Summary (PTO-413)  
Paper No(s)/Mail Date: \_\_\_\_\_
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: \_\_\_\_\_

## DETAILED ACTION

### *Continued Examination Under 37 CFR 1.114*

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 11/18/2003 has been entered.

### *Claim Rejections - 35 USC § 112*

2. The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

3. Claim 1 is rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter, which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Claim 1 recites, "each of the second layers having a thickness substantially equal to four times a thickness of each of the first layers" in the last two lines. The instant specification merely teaches a first layer with a thickness of 20 nm and a second layer of a thickness of 80 nm on page 12 of the instant specification, which inherently is a thickness of four times the thickness of a first layer. However, the claim is significantly broader than the specification and outside of the scope

provided by the specific example in the instant specification. Support for this broad limitation is not provided in the instant disclosure.

***Claim Rejections - 35 USC § 102***

4. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

5. Claims 1, 3-9 and 19-27 are rejected under 35 U.S.C. 102(e) as being anticipated by Sverdlov (US 6,266,355).

Sverdlov discloses a sapphire substrate **12** and a nitride semiconductor **18** (col 4, ln 5-25 and Figs 1 and 7). Sverdlov also discloses a cladding layer grown by digital alloying comprising growing monolayers of GaN and AlN forming a GaN/AlN superlattice. Sverdlov also discloses the ratio of GaN monolayers to AlN monolayer may be about 4:1 or 5:1 and can be extended to  $\text{Al}_x\text{Ga}_{1-x}\text{N}/\text{Al}_y\text{Ga}_{1-y}\text{N}$  superlattices, this reads on applicant's each of the second layers having a thickness substantially equal to four times a thickness of each of the first layers. Sverdlov also discloses the digital alloying provides for higher doping concentrations (col 2, ln 40 to col 3, ln 15). Sverdlov discloses the cladding layers provided for higher impurity concentration doping of GaN of higher than  $10^{18}$  can be achieved (col 4, ln 55-67). Sverdlov also discloses doping is

Art Unit: 1765

introduced during the growth of the monolayers of AlN and/or GaN and doping only the GaN monolayer during growth alleviates layer cracking. Sverdlov also discloses single or multiple monolayers of the different layers are possible (col 7, ln 15-55). Sverdlov discloses an Mg dopant and a Si dopant (col 7, ln 30-35 and col 7, ln 60-67).

Sverdlov is silent to the superlattice structure is a buffer. However, this is inherent because Sverdlov discloses a similar structure located between a substrate and a nitride semiconductor, as applicant.

Referring to claim 3, Sverdlov discloses Si and Mg (col 7, ln 15-67).

Referring to claims 4-5, Sverdlov discloses AlN, GaN and AlGa<sub>N</sub>, which reads on applicant's III-V semiconductor.

Referring to claim 6-9, Sverdlov discloses a sapphire substrate (col 4, ln 10-15).

Referring to claim 19, Sverdlov discloses a device **10** comprising the superlattice (col 4, ln 10-15 and Fig 1).

Referring to claim 20-26, Sverdlov discloses forming a light-emitting device using III-V semiconductors (col 4, ln 5-67 and Fig 1).

Referring to claim 27, Sverdlov is silent to the treading dislocation density is substantially equal to  $5 \times 10^7 \text{ cm}^{-2}$ . This is inherent to Sverdlov because Sverdlov discloses a layer with a similar structure of a superlattice doped and undoped layers on a similar substrate with similar dopant concentrations, as applicant, note page 6, ln 18-25. Therefore a similar structure would be expected to inherently have similar properties.

6. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

7. Claims 1, 3-9 and 19-27 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nagahama et al (US 6,172,382) or Kiyoku et al (US 6,153,010) in view of Sverdlov (US 6,266,355).

Nagahama et al discloses a method of forming a nitride semiconductor light emitting and light receiving device, note entire reference, comprising a sapphire substrate **30** and a n-side cladding layer **14** composed of superlattices obtained by laminating one-hundred-twenty GaN layers doped with Si to  $1 \times 10^{19}/\text{cm}^3$ , this reads on applicant's an impurity at a concentration exceeding its doping level, and one-hundred-twenty undoped  $\text{Al}_{0.1}\text{Ga}_{0.9}\text{N}$  layers respectively by turns and a p-side cladding layer **19** composed of superlattices obtained by laminating GaN

Art Unit: 1765

layers doped with Mg to  $1 \times 10^{20}/\text{cm}^3$  and undoped  $\text{Al}_{0.1}\text{Ga}_{0.9}\text{N}$  layers (Example 27, 33 and 35). Nagahama et al also discloses forming a p-side contact layer **20** of p-type GaN doped with Mg on the p-side cladding layer **19**. Nagahama et al also discloses the super lattice structure can nitride layers improved in crystallinity (col 2, ln 1-67) and n-impurities include IV-A, IV-B, VI-A and VI-B groups and p-impurities belong to I-A, I-B, II-A and II-B groups (col 4, ln 1-67). Nagahama et al also discloses the material of the substrate may include sapphire, SiC, or other material which are different from nitride semiconductors and are known for growing nitride semiconductors such as GaAs (col 55, ln 35-67).

Kiyoku et al discloses a method of forming a nitride semiconductor device, note entire reference, comprising a wafer, this reads on applicant's substrate, set in a MOVPE reaction vessel and forming a n-side cladding layer **213** having a superlattice structure by alternately stacking a total of 100 20-angstrom thick first layers, each made of n-type  $\text{Al}_{0.2}\text{Ga}_{0.8}\text{N}$  doped with Si at  $5 \times 10^{18}/\text{cm}^3$  and 20-angstrom thick second layers made of undoped GaN (Example 7). Kiyoku et al et al also discloses the threshold of a device can be decreased by performing modulated doping, where a p-die cladding layer **218** can be formed by alternately stacking first thin layers made of AlGaN doped with a Mg and second thin layers made of undoped GaN (col 23, ln 1-67). Kiyoku et al also discloses the substrate can be made of sapphire, SiC, GaAs or Si (col 7, ln 1-67). Kiyoku et al also discloses a buffer layer **81** has a distorted superlattice structure formed by alternately stacking an AlGaN doped with n-type impurity and undoped GaN layers, where a buffer with a superlattice structure can provide an n-side cladding layer having excellent crystallinity (col 20, ln 1-67).

Nagahama et al and Kiyoku et al does not teach each of the second layers having a thickness substantially equal to four times the thickness of each of the first layers.

In a method of making a superlattice, note entire reference, Sverdlov teaches for every layer of AlN a group of GaN layers are grown and any ratio to provide a desired average composition of material can be used. Sverdlov also teaches a ratio of 4:1 and using single or multiple monolayers for the different layers (col 7, ln 15-67). Sverdlov also discloses doping with Si or Mg and superlattices of  $\text{Al}_x\text{Ga}_{1-x}\text{N}/\text{Al}_y\text{Ga}_{1-y}\text{N}$  (col 7, ln 60 to col 8, ln 35).

It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Nagahama et al or Kiyoku et al by using a ratio of four in forming a superlattice, as taught by Sverdlov, to form a desired average composition.

Referring to claim 27, the combination of Nagahama and Sverdlov or the combination of Kiyoku et al and Sverdlov is silent to the threading dislocation density is substantially equal to  $5 \times 10^7 \text{ cm}^{-2}$ . This is inherent to the combination of Nagahama and Sverdlov or the combination of Kiyoku et al and Sverdlov because the combination of Nagahama and Sverdlov or the combination of Kiyoku et al and Sverdlov teaches a layer with a similar structure of a superlattice doped and undoped layers on a similar substrate with similar dopant concentrations, as applicant, note page 6, ln 18-25. Therefore a similar structure would be expected to inherently have similar properties.

8. Claim 2 is rejected under 35 U.S.C. 103(a) as being unpatentable over Sverdlov (US 6,266,355); or Nagahama et al (US 6,172,382) or Kiyoku et al (US 6,153,010) in view of



Art Unit: 1765

Sverdlov (US 6,266,355) as applied to claim 1 above, and further in view of Kumakura et al (“Increased Electrical Activity of Mg-Acceptors in  $\text{Al}_x\text{Ga}_{1-x}\text{N}/\text{GaN}$  Superlattices”).

Sverdlov or the combination of Nagahama and Sverdlov or the combination of Kiyoku et al and Sverdlov teaches all of the limitations of claim 2, as discussed previously, except the thickness of the first layer is substantially 20 nm and the thickness of the second layer is substantially 80 nm.

In a method of making a superlattice, note entire reference, Kumakura et al teaches the hole concentration per period of a superlattice is affected by the period thickness of an  $\text{AlGaIn}/\text{GaIn}$  superlattice (pg 1012 and Fig 1). Kumakura et al also teaches the period thickness ranging from 90-1000 angstroms (9-100nm).

It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Sverdlov or the combination of Nagahama and Sverdlov or the combination of Kiyoku et al and Sverdlov by optimizing the thickness of the layers of the superlattice to obtain the thicknesses claimed by applicants by conducting routine experimentation of a result effective variable because Kumakura et al teaches that the period thickness of a superlattice affects the hole concentration. Furthermore, layer constituting a superlattice are well known in the art to vary between 1-100 nm, as evidenced by Sakai et al (US 6,475,882) below.

9. Claim 2 is rejected under 35 U.S.C. 103(a) as being unpatentable over Sverdlov (US 6,266,355); or Nagahama et al (US 6,172,382) or Kiyoku et al (US 6,153,010) in view of Sverdlov (US 6,266,355) as applied to claim 1 above, and further in view of Bour et al (US 5,977,612).

Sverdlov or the combination of Nagahama and Sverdlov or the combination of Kiyoku et al and Sverdlov teaches all of the limitations of claim 2, as discussed previously, except the thickness of the first layer is substantially 20 nm and the thickness of the second layer is substantially 80 nm.

In a method of making a superlattice, note entire reference, Bour et al (US 5,977,612) teaches the thickness of individual AlGa<sub>N</sub> or Ga<sub>N</sub> layer of s superlattice depends upon the desired output wavelength of a layer. Bour et al also teaches a thickness of 40 nm to produce an emission at 420 nm (col 5, ln 40 to col 6, ln 5).

It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Sverdlov or the combination of Nagahama and Sverdlov or the combination of Kiyoku et al and Sverdlov by optimizing the thickness of the layers of the superlattice to obtain the thicknesses claimed by applicants by conducting routine experimentation of a result effective variable to obtain a desired output, as taught by Bour et al. Furthermore, layers constituting a superlattice are well known in the art to vary between 1-100 nm, as evidenced by Sakai et al (US 6,475,882) below.

10. Claims 1-9 and 19-27 are rejected under 35 U.S.C. 103(a) as being unpatentable over Razeghi (US 5,831,277) in view of Kiyoku et al (US 6,153,010).

Razeghi teaches a substrate of GaAs, Si, Sapphire, MgO, SiC, ZnO, or GaN (col 3, ln 35-45) and a superlattice grown by alternating Ga<sub>N</sub> (0.25-30 angstroms) with AlGa<sub>N</sub> (0.5-1 angstroms) to a total thickness of less than 5000 angstroms, this reads on applicant's second layer having a thickness of four times a thickness of a first layer because 1 angstrom AlGa<sub>N</sub> is

Art Unit: 1765

four times the thickness of 0.25 angstrom thick GaN. Razeghi also teaches forming a photoemitter device an upper and lower contact layer and upper confinement layer comprising a superlattice and an active layer (claim 1). Razeghi also teaches a cap layer of GaN is deposited on the superlattice (col 5, ln 20-40), this reads on applicant's nitride semiconductor as a device material. Razeghi also teaches a p-type doping of greater than  $2 \times 10^{17} \text{ cm}^{-3}$  using Mg, Be, Zn or Cd (claim 6 and 10).

Razeghi does not teach a plurality of second layers containing no impurity.

In a method of forming a superlattice, note entire reference, Kiyoku et al teaches the threshold of LD device can be decreased by performing modulated doping comprising doping either the first layer or the second layer with an impurity at a high concentration. Kiyoku et al also teaches a cladding layer comprising a first layer of AlGa<sub>N</sub> doped with Mg and a second layer made of undoped GaN (col 23, ln 15-65). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Razeghi with Kiyoku et al modulated doping to reduce the threshold of a device.

Layers constituting a superlattice are well known in the art to vary between 1-100 nm, as evidenced by Sakai et al (US 6,475,882) below. Therefore, It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Razeghi and Kiyoku et al by using the thickness claimed by applicants to obtain a desired property because layer thickness is a result effective variable, as evidenced by Kumakura et al ("Increased Electrical Activity of Mg-Acceptors in Al<sub>x</sub>Ga<sub>1-x</sub>N/GaN Superlattices") and Bour et al (US 5,977,612) above.

***Response to Arguments***

11. Applicant's arguments with respect to claims 1-9 and 10-27 have been considered but are moot in view of the new ground(s) of rejection.

***Conclusion***

12. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Sakai et al (US 6,475,882) teaches each of the layers constituting a superlattice layer may have a thickness of 1-100 nm (col 8, ln 25-50).

Ishida et al (US 6,198,112) teaches n-type impurities are Si, Se, S and the like and p-type dopants are Mg, Zn, Be and the like for GaN (col 3, ln 10-40 and col 4, ln 1-5).

Nakamura et al (US 5,578,839) teaches dopant concentration affects the relative light intensity (Fig 9-10) and an InGaN layer with a dopant concentration within a range of about  $10^{17}/\text{cm}^3$  to  $1 \times 10^{22}/\text{cm}^3$  (col 7, ln 30-40).

Nikolaev et al (US 6,218,269) teaches an III-V nitride semiconductor layer with an acceptor concentration in a range between  $10^{17} \text{ cm}^{-3}$  and about  $10^{21} \text{ cm}^{-3}$  (col 4, ln 20-35).

Shih et al (US 5,874,320) teaches a gallium nitride is doped with magnesium to form a P-type GaN until its concentration is on the order of  $10^{20} \sim 10^{21} \text{ cm}^{-3}$  (col 2, ln 35-50).

13. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Matthew J Song whose telephone number is 571-272-1468. The examiner can normally be reached on M-F 9:00-5:00.

Art Unit: 1765

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine Norton can be reached on 571-272-1465. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Matthew J Song  
Examiner  
Art Unit 1765

MJS

NADINE G. NORTON  
PRIMARY EXAMINER

